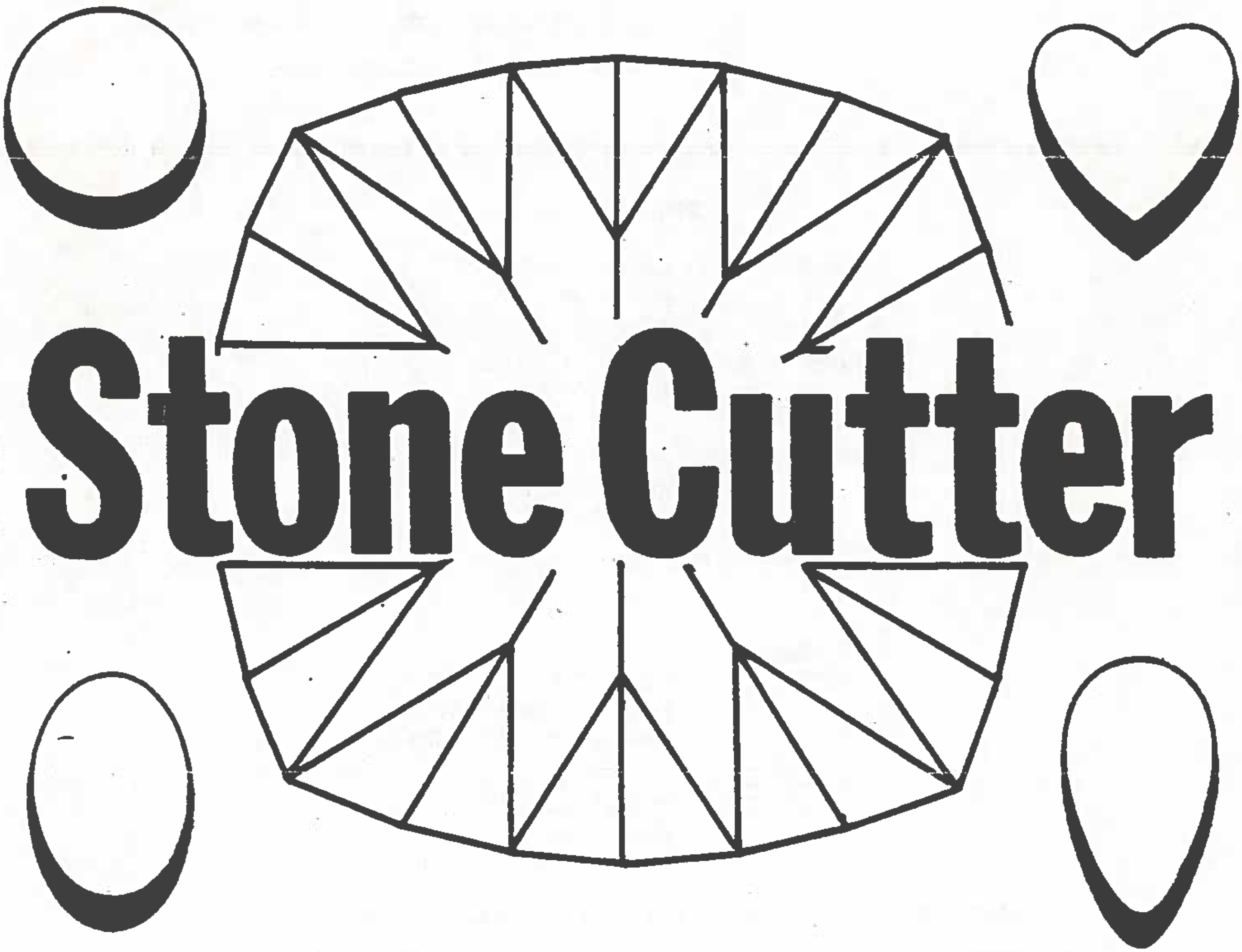
NORTH CAROLINA LAPIDARY SOCIETY

July
1982

Stone Cutter



MEETINGS:
Third Thursday each month.
GEMCRAFTERS
2106 Patterson St.
Greensboro, NC 27407

SOUTHEAST FEDERATION MINERALOGICAL SOCIETIES, INC.

MEETING DATE : July 15, 1982

TIME : 7:30 PM

PLACE : GEMCRAFTERS
2106 Patterson St.
Greensboro, NC

PROGRAM : DESIGNING FACET CUTS - Tom Ricks will discuss facet designing and demonstrate with slides how you can design your own stone - without mathematics!

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Rt. 3 Box 347
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The DOUBLE-NINE and STROBE

by Paul C. Smith
Indianapolis, IN

EDITOR'S NOTE: This excellent article by designer Paul Smith is a very timely follow-on to our discussions at the June meeting concerning the critical angle of gem materials and the behavior of light within the stone. Of necessity some of points are expressed in mathematical terms but Paul has kept the math to an easily understood minimum. Even if you choose to ignore the math, the two new facet designs included will be interesting to most if not all faceters. TJR.

Here are a couple of facet designs that are very easy to do -- no challenge to the experienced faceter. On paper they look so simple that your first impression might be "Why should I try these cuts -- they are too simple to be worthwhile." Don't let that fool you or keep you from trying them. The results will surprise you.

First, a little background theory to explain their effectiveness. They are cut using a 72-index gear. Why is that good? Because it allows you to cut 9 equally spaced pavilion facets (two sets of nine in the Double-Nine cut) none of which is directly opposite another one. Why is <u>that</u> good? I'll try to explain with the help of a few diagrams.

Figure 1 shows the path a ray of light might take inside a stone cut in the time-honored manner -- a standard brilliant, perhaps. Only the pavilion mains are considered -- the rest are not too important for this discussion.

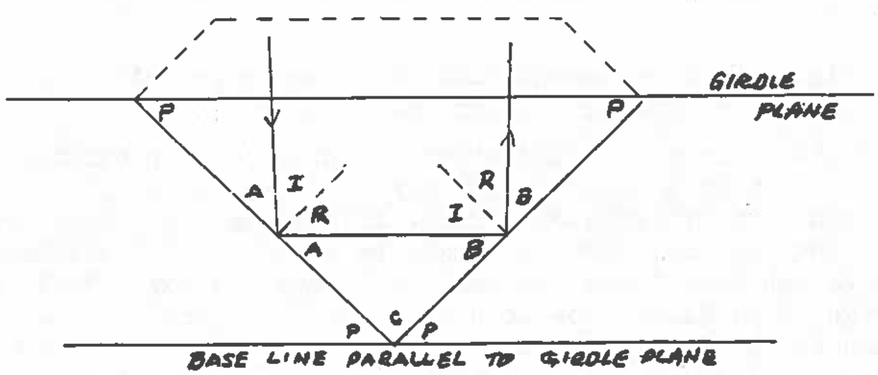

Figure 1. This is a cross-sectional view such as you would get if you cut the stone by a vertical plane through its center and perpendicular to your line of sight. You are looking at the edges of two facets indexed 180 degrees apart -- say at 48 and 96 on a 96-tooth gear.

The light ray enters the gem and strikes one pavilion facet, is reflected across to the pavilion facet directly opposite, and is reflected again up to the crown, out the crown and into the viewer's eye. The dotted lines are the

normals to each pavilion facet. "Normal" is just mathematical jargon for perpendicular.

An optical law says that the angle of incidence, I, is equal to the angle of reflection, R. This is true of any reflecting surface, whether it is flat, convex, or concave. Since all good, respectable faceters always cut flat facets we can also say that the two angles, A, are equal and the two angles, B, are equal. But in only one case is A equal to B; when the ray crosses parallel to the girdle plane.

A basic theorem in geometry says that the sum of all angles in a triangle equals 180 degrees. Another says that a straight angle equals 180 degrees. Therefore the sum of the angles in the triangle at the culet is A+B+C = 180. Also P+P+C = 180. Or A+B+C = P+P+C. If we take away C from both sides of the equation we have:

A+B = 2P

This is always true whether the ray crosses parallel to the girdle plane or at a slant, for if A becomes smaller by any given amount, B becomes larger by the same amount, and vice versa.

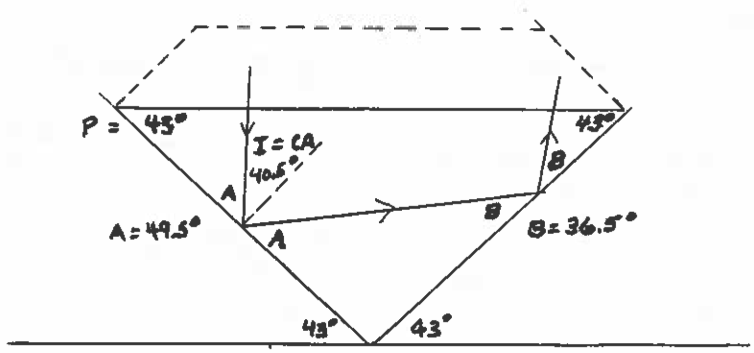

Figure 2. A representation of a quartz gem with pavilion angles, P, cut at 43 degrees.

Taking the refractive index of quartz at 1.54, the critical angle, CA, is 40.5 degrees. In Figure 2. the light ray is drawn so that I=CA. This makes angle A=90 minus 40.5, or 49.5 degrees. If A is made any greater, the ray will fall inside the critical angle cone and be lost out the left-hand pavilion facet. But we can make A smaller and still have the ray totally reflected toward the right-hand facet. How much smaller? In Figure 3., angle A is shown as 36.5 degrees and B has a value of 2P - A = 86 -36.5, or 49.5 degrees. If we make A any smaller, B will be greater than 49.5 degrees and the ray will be lost out the right-hand facet.

So we see that both A and B can vary only between 36.5 and 49.5 degrees, a range of 13 degrees. Obviously it is desirable to have this range as great as possible; the more rays we can reflect off the pavilion facets to the crown, the brighter our stone will be. Is there some way this range could be increased? Yes, one way is to cut the pavilion facets at a lower angle, but that brings in other effects, which is another story. Another way is to move one facet from its 180-degree relation to the other facet. That's where the 72-index comes in.

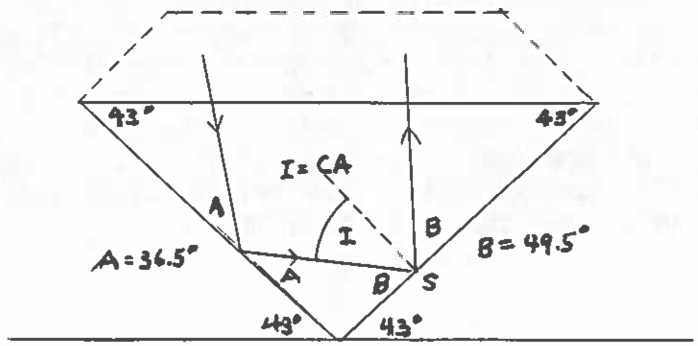

Figure 3

Figure 4 is a pavilion diagram showing nine facets spaced 40 degrees apart (9x40=360). The line starting at point R is the path of a ray striking facet P 1 in such a manner that it is reflected directly across the pavilion to strike facet P 2 at some point S. The dotted triangle indicates the position of a facet if cut directly opposite facet P 1, as in Figures 1, 2, and 3. Facets P 2 and P 3 are indexed 20 degrees away from this facet.

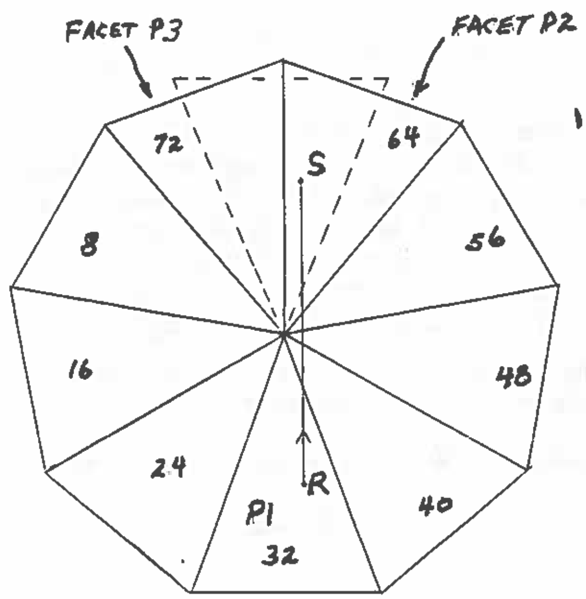

Figure 4

Now we are going to test your powers of visualization. The boundary between reflected and transmitted rays as they strike the interior surface of a facet, such as the right-hand facet in Figure 3, can be described as the surface of a cone. In Figure 3, imagine such a cone being generated by rotating the line ABS about the normal to the facet at point S, always keeping the angle I equal to CA. Then any ray striking point S and falling within the cone will be lost out the pavilion. Any ray striking point S and falling outside the cone will be reflected.

Figure 5 shows a perspective view of the dotted facet in Figure 4. The critical-angle cone is shown, using the same values as in Figure 3. The ray coming from the opposite facet just grazes the surface of the cone. Now, it should be easy to visualize what happens as the facet rotates away from the 180-degree position, either to facet P 2 or P 3. The cone moves away from the ray, and angle B can be increased a certain amount until it again touches the surface of the cone. Tha amount of increase can be calculated by a fairly complex trig formula (which ye author has developed).

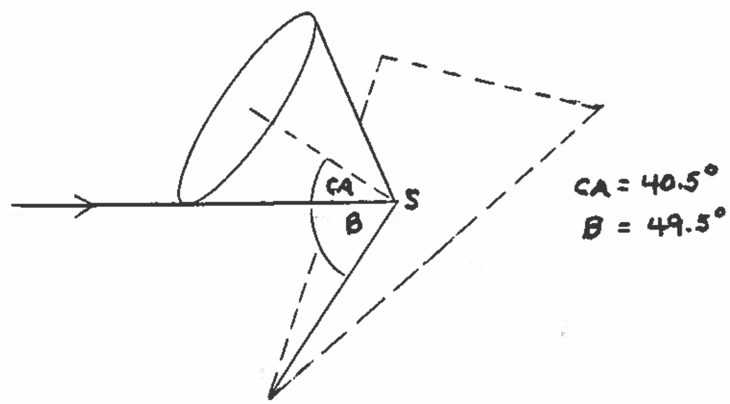

Figure 5

It turns out that the range of angles A and B is increased from the original 13 degrees in Figures 2 and 3 to 16.7 degrees, an improvement of 28.5%. If the facets are all cut at 41 degrees, (CA still 40.5 degrees) the range changes from 17 degrees to 20.5 degrees, an improvement of 20.6%. The percent of improvement is less, but you are still ahead of the game because of the greater final range. This has turned out to be a rather involved explanation, but the ideas and principles are useful in studying other designs, too.

I believe that the foregoing explanation accounts, to a great extent, at least, for the performance of the 9-symmetry cuts (and other odd-symmetry cuts).

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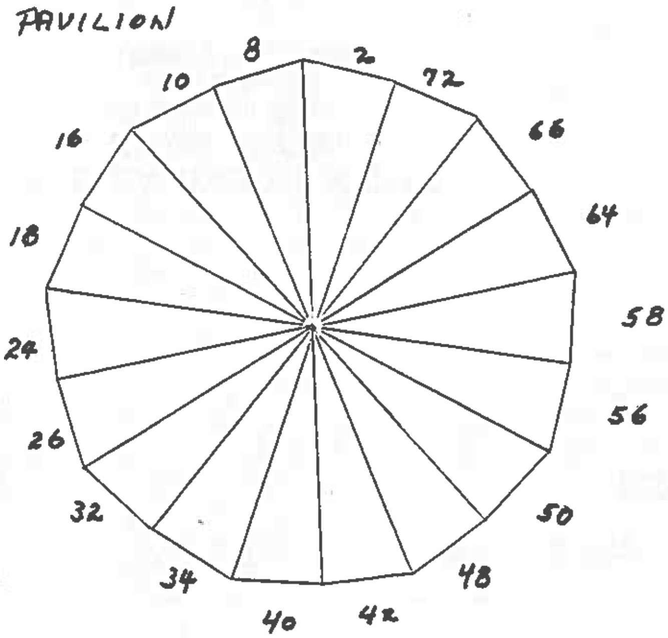
DOUBLE NINE

DESIGNER'S COMMENTS

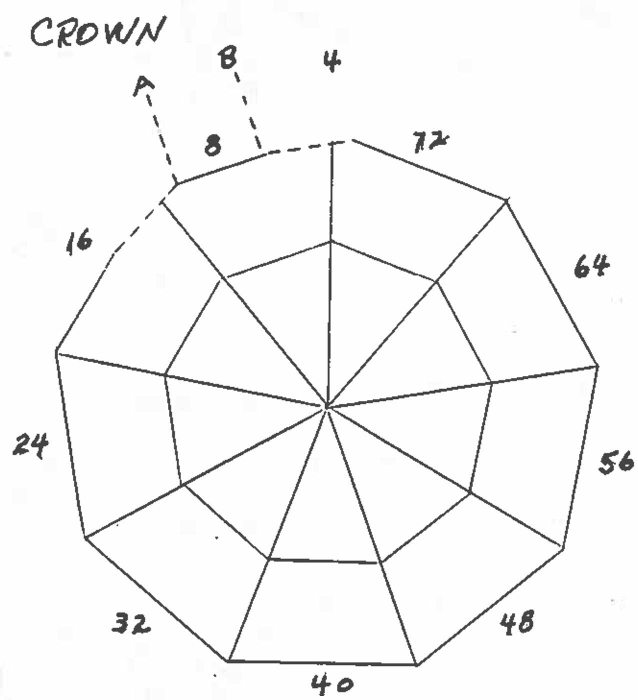
1. Cut the pavilion first.
2. The girdle is uneven except for a part of each crown main, as indicated between dotted lines A and B on the crown diagram. The true appearance of the girdle outline as viewed from above is shown by dotted lines at facets 8, 16, and 72.
3. The designer's machine mounts the stone on one end of the dop and the index gear on the other. The gear is numbered clockwise but as the gem is viewed during cutting, the facets are in counter-clockwise order. therefore the diagrams are numbered counter-clockwise. If your machine gives you clockwise numbered facets, use these index numberd, regardless. Your finished gem will show a mirror image of the crown girdle outline.

DOUBLE NINE - Cutting instructions.



PAVILION

STEP	ANGLE	INDEX	COMMENTS
1.	90°	02-08-10-16 18-24-26-32 34-40-42-48 50-56-58-64 66-72	Cut to same stop and equal girdle facets.
2.	42°	Same as above.	Cut to meet at culet



CROWN

STEP	ANGLE	INDEX	COMMENTS
1.	41°	08-16-24-32 40-48-56-64 72	Cut for desired girdle thickness.
2.	8°	As above	Cut for good meets in center and about 60% of stone diameter.

Depth-toDiameter Ratio -- Approx. 68%.
72-INDEX. Angles for quartz.

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6852 Jonquil Terr.
Niles, IL 60648

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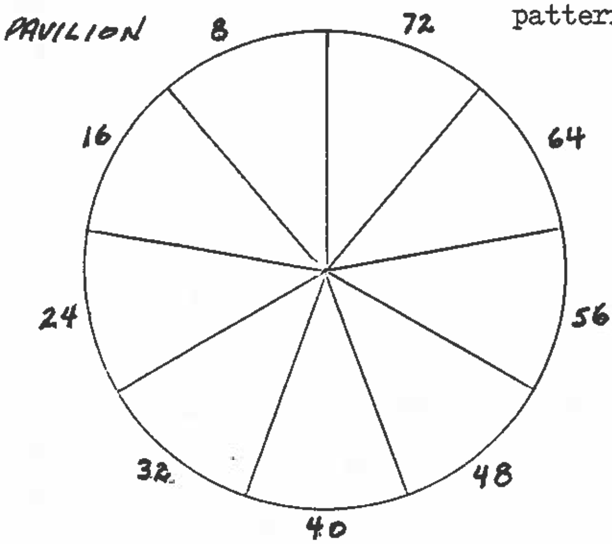
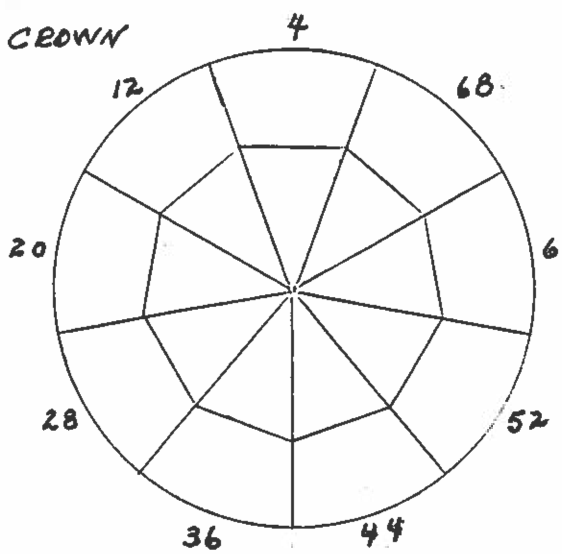
STROBE

(Light pattern resembles pattern of stroboscope disc.)



PAVILION

STEP	ANGLE	INDEX	COMMENTS
1.	90^{o}	-------	In free wheeling cut round girdle to desired diameter.
2.	43^{o}	08-16-24-32-40 48-56-64-72	Cut to same stop and good meets at culet.



CROWN

STEP	ANGLE	INDEX	COMMENTS
1.	39^{o}	04-12-20-28-36 44-52-60-68	Cut to desired girdle thickness. Girdle will be wavy.
2.	8^{o}	Same as above.	Cut to good meets in center and about 60% of stone diameter.

Depth-to-Diameter Ratio -- Approx. 70%.
72 INDEX. Angles for quartz.